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TECHNICAL MEMORANDUM

(TM Series)

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General Purpose
Satellite Computer Program Descriptions
Milestone XI
Correction Apparent Elevation for Refraction (RC)

by
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9 November 1962
Approved
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2500 COLORADO AVE.
SANTA MONICA
CALIFORNIA

SUBROUTINE IDENTIFICATION

A. Title: Correct Apparent Elevation for Refraction (RC) - Ident. F99, Mod. NS

B. Programmed: J. C. Lenhoff, Lockheed Missile and Space Division

C. Revised and Documented: 9 November 1962, Nancy Speer System Development Corporation.

PURPOSE

RC corrects for refraction any number of apparent elevations which are within the range 0 to 2π.

USAGE

A. Calling Sequence:

```
L       RTJ     RC
L+1     ZRO     EA
        ZRO     N
L+2     Normal Return
```

where: EA = the location of the first elevation to be corrected
N = the number of elevations to be corrected

B. Inputs:

The input elevations must be expressed as floating-point radians within the range 0 to 2π.

C. Results:

Each corrected elevation, as a radian value in floating-point format, is placed in the location of the input elevation. The correction factor is stored in the first cell of COMMON.

METHOD

RC picks up the first apparent elevation and, if it falls in the second quadrant, reduces it to its supplement. Angles in the third and fourth quadrants are taken as +0. The resulting reduced angel is used as the basis for determining the correction factor to be applied.

The correction factor is found, with the use of INDIV, by linear interpolation within the independent and dependent variable tables contained in RC. The independent variable table has 59 entries of

apparent elevations (E_A) from 0 to $\pi/2$; the dependent variable table has 59 values for refraction correction corresponding directly to the values in the first table. Each entry (d) in the dependent variable table was pre-computed as:

$$d = 2/\left\{(\tan E_A) + \left[2\ (H/R - M_0) + \tan^2 E_A\right]\right\}^{\frac{1}{2}}$$

where: EA = the apparent elevation

H = emperical constant scale height

R = radius of the earth

$H/R \cong .00303$

M_0 = index of refraction at the earth's surface -1, $M \cong .00033$

When INDIV yields the value of d, RC multiplies it by M_0. The resulting correction factor is stored in COMMON.

Before the factor is applied, RC determines the quadrant in which the apparent elevation was originally. If it was in the first quadrant, the factor is subtracted from the original value; if in the second quadrant the factor is added. For angles in the third quadrant, the factor is added to π and for the fourth quadrant, the factor is subtracted from 0. The corrected elevation ther is stored in the location of the original apparent elevation.

This procedure continues until all specified apparent elevations have been corrected.

RESTRICTIONS

A. Accuracy

The results of RC fall well within the requirement of accuracy to the fourth decimal place. A more definite statement of accuracy can not be made because accuracy varies greatly depending on the magnitude of the input and its proximity to any pair of entries in the two tables used for interpolation.

B. Input Limits

Inputs must be within the range 0 to 2π. Inputs outside these limits will not be reduced properly and will cause an error return from INDIV which, in turn, causes a jump to SUBERR and consequent halt.

C. Environment

RC uses the subroutines INDIV and SUBERR, and the Reference Pool. Index registers 1 and 2 are saved, used, and restored.

TIMING

Maximum	243.6xN + 101.4 microseconds plus time for INDIV
Minimum	198.0xN + 101.4 microseconds plus time for INDIV
	where N = number of elevations

STORAGE REQUIREMENTS

A. Storage Allocation

Program	36_{10} cells
Constants	122_{10} cells
Temporary Storage	1 cell
	159 cells

B. Constants

In addition to the tables used for interpolation, RC contains the following constants:

TAG	DESCRIPTION	FORMAT
SMØ	.00033 (refraction index-1)	floating
PIE	3.1415926535897	floating
LØC1	1	fixed, scaled 2^{0}
CØMP	-0	fixed

C. Temporary Storage

RC uses the following cell as well as the first cell in the COMMON table.

TAG	DESCRIPTION
SAVE	holds reduced angle

VALIDATION TESTS

A. Test Inputs

The test program contained a table of 21 radian values which were used as inputs to RC. Appendix A gives these inputs and the results from RC.

B. Procedure

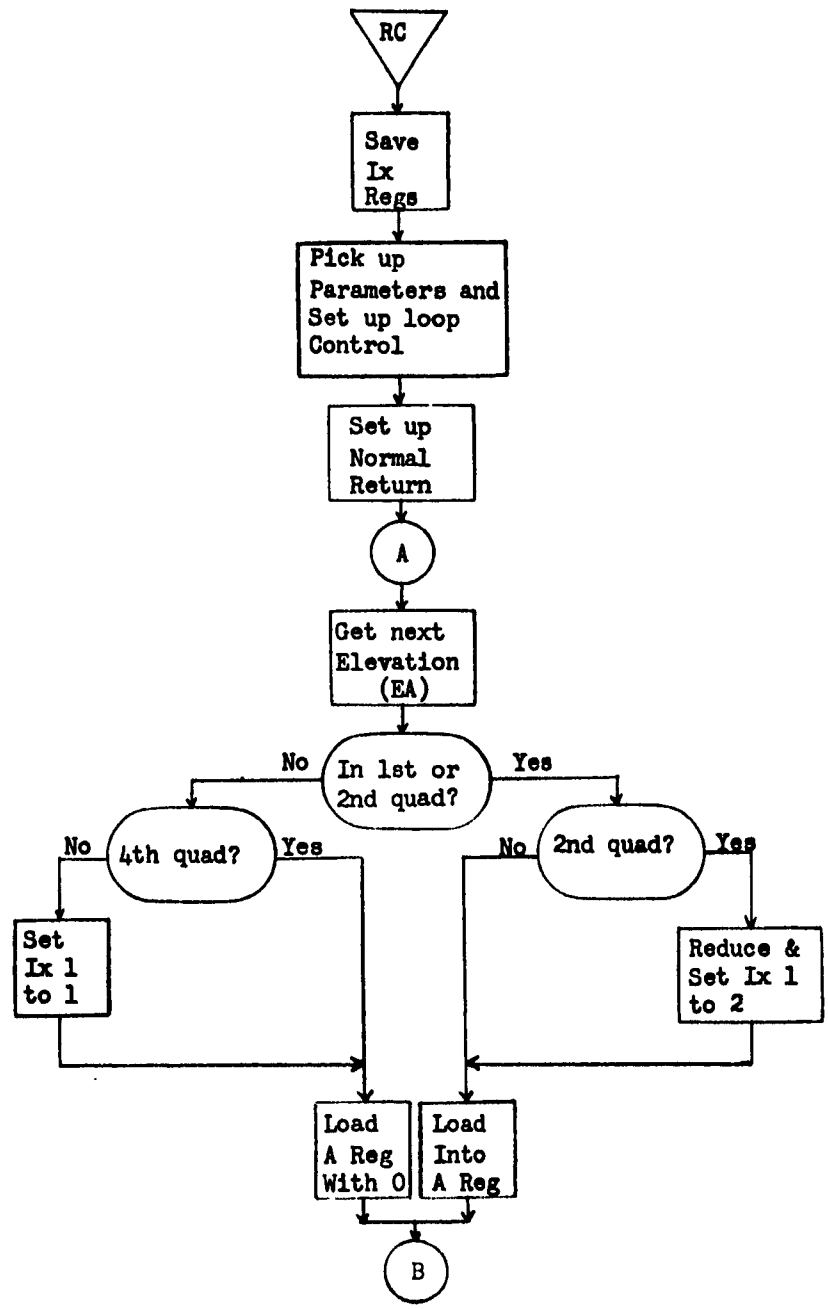
The test program was written as a callable function under MTCII control. The F99 mod. NS version of RC was incorporated as a re-defined function.

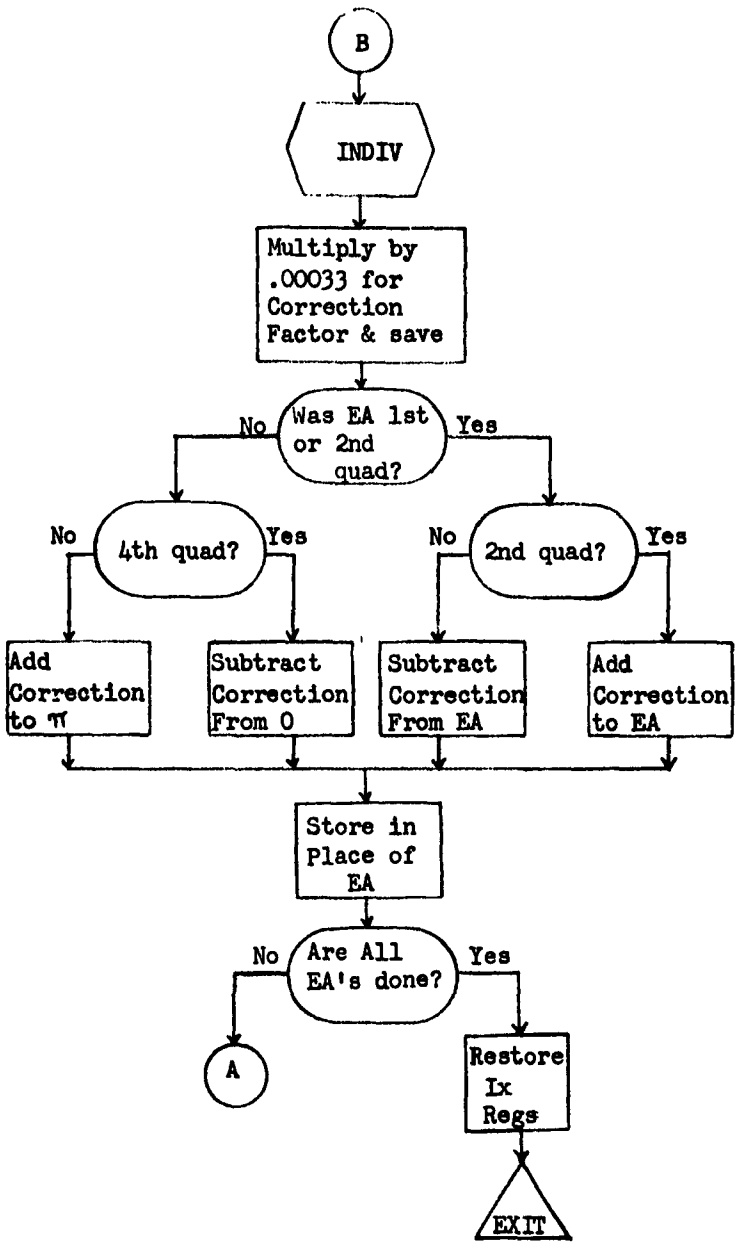
C. Results

RC gave the expected results in all cases.

REFERENCES

1. N-(L)-19126/000/00, Description of Revised RC
2. LMSC-447578, page 55.05.13, Systems Manual Subroutine Description of RC.
3. TM-(L)-715/025/00, Utility Program Descriptions, Milestone XI, Interpolate by Divided Differences (INDIV), (AFCPL #75024).
4. LMSD-447578, page 50.06.01, Systems Manual Subroutine Description of SUBERR.


RC
Save Ix Regs
Pick up Parameters and Set up loop Control
Set up Normal Return
A
Get next Elevation (EA)
In 1st or 2nd quad?
No
Yes
4th quad?
No
Yes
2nd quad?
No
Yes
Set Ix 1 to 1
Reduce & Set Ix 1 to 2
Load A Reg With 0
Load Into A Reg
B


B
INDIV
Multiply by .00033 for Correction Factor & save
Was EA 1st or 2nd quad?
No
Yes
4th quad?
No
Yes
2nd quad?
No
Yes
Add Correction to π
Subtract Correction From 0
Subtract Correction From EA
Add Correction to EA
Store in Place of EA
Are All EA's done?
No
Yes
A
Restore Ix Regs
EXIT

APPENDIX A

The test results in decimal radians are shown in the following table.

INPUT	RC RESULT
.05236	.04773382079
.20944	.2079312841
.38397	.3831598609
.40143	.4006583167
.61087	.6104000062
.80285	.8025315364
1.0	.9997881829
1.23918	1.239066350
1.55334	1.553334237
1.58825	1.588255762
1.78024	1.780310141
2.75762	2.758430133
2.67035	2.670994323
2.09444	2.094630537
3.1415926535897	3.150574116
3.158	3.150574116
4.712	3.150574116
4.72	-.008981462391
6.27	-.008981462391
5.06145	-.008981462391
0	-.008981462391

INTERNAL DISTRIBUTION LIST

Allfree, D.	22076	Hoyt, R. L.	14032
Alperin, N. I.	24118A	Imel, L. E.	14032
Armstrong, E.	24089	Kastama, P. T.	24053
Bernards, R. M.	Sunnyvale	Kayser, F. M.	25026
Biggar, D.	24090B	Keddy, J. R.	25026
Bilek, R. W.	24124	Key, C. D.	24123
Black, H.	14032	Keyes, R. A.	20073
Brenton, L.	22082	Kinkead, R. L.	24071
Burke, B. E.	22070	Kneemeyer, J. A.	24065A
Busch, R. E.	24065B	Knight, R. D.	24110B
Carter, J. S.	27032	Kolbo, L. A.	24139
Champaign, M. E.	24127B	Kostiner, M.	14048
Chiodini, C. M.	24075	Kralian, R. P.	14032
Ciaccia, B. G.	24082A	Kristensen, K.	Sunnyvale
Cline, B. J.	24097	LaChappelle, F.	24061
Cogley, J. L.	24135	Laughlin, J. L.	20073
Conger, L.	22076	LaVine, J.	24081
Cooley, P. R.	24083	Little, J. L.	24077
Court, T. D.	22070	Long, F.	24122
Dant, G. B.	22073	Lytton, J. G.	24082B
DeCuir, L. E.	22096A	Madrid, G. A.	24049
Derango, W. C.	20079	Mahon, G. A.	22073
Dexter, G. W.	24103A	Marioni, J. D.	24074A
Disse, R. J.	24123	Martin, W. P.	24089
Dobbs, G. H.	24094	McKeown, J.	24121
Dobrusky, W. B.	22119	Michaelson, S. A.	14032
Donnelly, S.	22082	Milanese, J. J.	24121
Ellis, R. C.	22078	Munson, J. B.	24048
Emigh, G. A.	14032	Myers, G. L.	14056A
Ericksen, S. R.	24110A	Nelson, P. A.	24075
Foster, G. A.	14032	Ng, J.	24049
Franklin, A.	22079	Ngou, L.	24030
Franks, M. A.	25030	Padgett, L. A.	24085
Frieden, H. J.	24071	Patin, O. E.	Sunnyvale
Gale, B.	22110	Polk, T. W.	24099
Greenwald, I. D.	24058A	Pruett, B. R.	24073
Griffith, E. L.	27029	Raybin, M.	14032
Haake, J. W.	24120	Reilly, D.	24085
Harris, E. D.	24083	Remstad, C. L.	27029
Henley, D. E.	24058B	Rosenberg, E. J.	14054
Henry, T. R.	24061	Rothman, S.	22116A
Hill, C. L.	24057	Russell, R. S.	14054
Holmes, M. A.	22079	Salisbury, L. W.	14052
Holzman, H. J.	22096B	Scholz, J. W.	14032
Houghton, W. H.	22073	Scott, R. J.	24093

INTERNAL DISTRIBUTION LIST (cont)

Seacat. C. M.		Sunnyvale
Seiden, H. R.		22091A
Shapiro, R. S.		25026
Skelton, R. H.		24127A
Solomon, J.		24053
Speer, N. J.		24081
Stone, E. S.		22116B
Swecney, M. J.		24057
Tennant, T. C.		27024
Testerman, W. D.		14032
Thompson, J. W.		22077
Thornton, R. L.		14032
Totschek, R. A.		24090A
Vorhaus, A. H.		24076A'
Wagner, I. T.		22078
West, G. D.		24117
West, G. P.		24094A
Wilson, G. D.		22101
Winsor, M. E.		24137
Winter, J. E.		24097
Wise, R. C.		24051
Wong, J. P.		Sunnyvale
Zubris, C. J.		22070
AFCPL	(5)	14059

UNCLASSIFIED

System Development Corporation,
Santa Monica, California
GENERAL PURPOSE SATELLITE COMPUTER
PROGRAM DESCRIPTIONS MILESTONE XI
CORRECT APPARENT ELEVATION FOR
REFRACTION (RC).
Scientific rept., TM-714/032/00,
by N. Speer. 9 November 1962, 7p.,
4 refs.
(Contract AF 04(695)-40)
Unclassified report

DESCRIPTORS: Programming (Computers).
Satellite Networks.

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Reports that RC (Correct Apparent
Elevation for Refraction) corrects
for refraction any number of
elevations which are within the
range 0 to 2 π .

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